A TAXONOMIC COMPARISON OF *ARISTIDA TERNIPES* AND *ARISTIDA HAMULOSA* (GRAMINEAE)[1]

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ABSTRACT

The morphologic similarity of *Aristida ternipes* and *A. hamulosa* was assessed. All 29 measured variables exhibited considerable overlap in their ranges, and only eight of the 29 had correlations greater than 0.50. Multivariate (principle component and discriminant) analyses revealed a lack of phenetic patterning; only awn lengths distinguished the taxa. The two entities are recognized at the varietal level. The nomenclatural combination *A. ternipes* var. *hamulosa* (Henrard) Trent is made.

RESUMEN

Se evalus la similitud morfolsgica entre *Aristida ternipes* y *A. hamulosa*. Las 29 variables medidas mostraron considerable supetposicisn, y solamente ocho de ellos dieron correlaciones mayores que 0.50. Un analisis multivariada revels una carencia de patrones feniticos; unicamente la longitud de las aristas sirvis para distinguir los taxa. Las dos entidades son reconocidas a nivel variedad. Se propone la combinacisn *A. ternipes* var. *hamulosa* (Henrard) Trent.

Two commonly encountered grasses in the southwestern United States are *Aristida ternipes* Cav. and *A. hamulosa* Henr. Both are common on dry, sandy plains and hills of low desert areas, and not infrequent at higher elevations in foothills and on mesa slopes. In general habit the two species are quite similar, with small basal tufts of foliage and large, stiff, widely spreading panicles. They differ most conspicuously in the development of their lateral awns, those of *A. ternipes* being very short (often hardly noticeable) and those of *A. hamulosa* being well-developed and obvious. Henrard (1927, p. 221) also called attention to the "curious" tuberculate lemmas of *A. hamulosa* when he described the species. The difference in awn lengths

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has traditionally placed the two species into separate sections of the genus: *A. ternipes* in the section *Streptachne*, and *A. hamulosa* in the section *Aristida* (*Chaetaria*) (Henrard 1929, 1932). However, the two species seem to be more similar than this classification would suggest.

Most North American botanists (Hitchcock and Chase 1951; Kearney and Peebles 1969; Beetle 1983) have accepted Hitchcock's (1924) and Henrard's (1926, 1928) treatment of *Aristida ternipes* and *A. hamulosa* as separate entities without evident relationship. Correll and Johnston (1970) suggested that *A. hamulosa* may be only a form of *A. divaricata*, but Gould (1951, 1975) called attention to the similarity of *A. hamulosa* with both *A. ternipes* and *A. divaricata*.

The purpose of this study was to evaluate the taxonomic relationship of *Aristida ternipes* and *A. hamulosa* by assessing the variability in morphological features and by testing the characters that traditionally have been used to separate them.

TABLE 1. Summary of acronyms and states for characters used in the statistical analysis of *Aristida ternipes* and *A. hamulosa*.

Character scored	Acronym	States
Culm height	CULMHT	Continuous
Blade width	BLADEW	Continuous
Blade conformation	BLADECON	0-flat 1-some involution 2-highly involute
Blade pubescence	BLADEPUB	0-glabrous 1-some pubescence 2-strongly pubescent
Collar pubescence	COLLPUB	0-glabrous 1-some pubescence 2-strongly pubescent
Ligule length	LIGULEL	Continuous
Panicle length	PANL	Continuous
Longest primary branch length	PRIBRNL	Continuous
Distance to first spikelet	SPKLTDIS	Continuous
First secondary branch length	SECBRNL	Continuous
Terminal primary branch length	TERMBRNL	Continuous
Lateral pedicel length	PEDL	Continuous
Maximum number of branches per node	BRNCHNUM	Continuous
Panicle branch spreading (Branching Index)	BRANINDX	ratio of spreading secondary and tertiary branches to the number of primary branches

Central awn length	CAWNL	Continuous
Lateral awn length	LATAWNL	Continuous
First glume length	FSTGLUML	Continuous
Second glume length	SECGLUML	Continuous
Glume pubescence	GLUMEPUB	0-glabrous 1-some pubescence 2-highly pubescent
Callus length	CALLUSL	Continuous
Floret length	FLORETL	Continuous
Width of lemma at widest point	LEMMAW	Continuous
Width of lemma at narrowest point	LEMMAN	Continuous
Lemma texture	LEMMATXT	0-smooth 1-tuberculate 2-scabrous
Awn column length	AWNCOLL	Continuous
Awn column twisting	COLLTW	0-no twisting 1-1 turn 2-2 or 3 turns 3-4 or more turns
Anther length	ANTHERL	Continuous
Palea length	PALEAL	Continuous
Elevation of collection site	ELEV	Continuous

MATERIALS AND METHODS

Field collections of *Aristida ternipes* and *A. hamulosa* were made from populations in Arizona, Colorado, New Mexico, Texas, and Chihuahua, Mexico; emphasis was placed on collecting all forms present in a population. The field collections were supplemented by herbarium material from throughout the range of the species, including California, Mexico, and Guatemala. From all material gathered, specimens were selected for study that represented the variability present in the two taxa as well as the geographic range of the species. A data set for morphometric analysis was compiled by scoring selected specimens (field and herbarium) for the features listed in Table 1. Only mature specimens were included in the analysis, determined by complete emergence of the panicle from the sheath. A total of 92 individuals were measured. A list of specimens examined may be requested from Allred.

The BMDP statistical package (Dixon 1981) was used for analysis. In addition to standard, descriptive statistics such as mean, range, standard deviation, and correlation coefficients for all variables, principal components analysis (PCA) was used to assess the morphological similarity or dissimilarity of the specimens (OTUs). Based on a variable by variable correlation matrix, the PCA plotted the OTUs along each component according to its phenetic similarity to each other OTU. Groups, or classifications of the OTUs, suggested by the PCA were then tested by stepwise discriminant analysis (SDA). SDA determined the potential for variables to cause disjunctions between two or more a priori groupings (in this case, those implied by PCA or those specified by a particular variable). A "grouping variable" segregated the OTUs into groups and the analysis determined if these groups were recognizable by the statistical relationships of the remaining variables. Output from SDA included the percentage of OTUs classified "correctly" or "incorrectly," that is, the percentage corresponding to the a priori groups. A high percentage of correctly classified OTUs indicated that the a priori classification was supported by the other variables. SDA was also used to test the importance or validity of certain variables in creating groups. Lateral awn length was used as the grouping variable, specifying two groups based on a cut-point value of 2.5 mm (those OTUs with lateral awns less than 2.5 mm were assigned to *ternipes*, those with lateral awns less greater than 2.5 mm were assigned to hamulosa). The SDA then determined if the resultant groups were supported statistically by the remaining variables.

RESULTS AND DISCUSSION

Morphometric Analysis. Correlation coefficients were calculated for all combinations of characters. All of the correlations greater than 0.50 were with continuous size variables (Table 2), but, the only variables that showed correlations higher than 0.80 were panicle and spikelet features related to specimen size: culm height with panicle length (0.86), primary branch length with panicle length (0.86), central awn length with lateral awn length (0.84), and first with second glume length (0.84). In general, as the size of the specimen increased, the size of the panicle also increased; likewise, the size of spikelet parts tended to increase or decrease in concert. It is noteworthy that lemma texture had no high correlations, eventhough Aristida hamulosa had been characterized by its prominent tubercles on the lemma (Henrard 1927).

The means and ranges of features with correlations higher than 0.50 were then compared between *Aristida ternipes* and *A. hamulosa* (Figure 1). The assignment of OTUs to one of the two taxa was based on lateral awn length because of its traditional importance in identification. OTUs with lateral awns longer than 2.5 mm were assigned to hamulosa, and those with shorter awns to *ternipes*. With the exception of the awn features, the ranges and standard deviations of every character overlapped extensively. Central awn length had overlapping ranges, but not standard deviations. Lateral awn lengths did not overlap because of the a priori assignment of

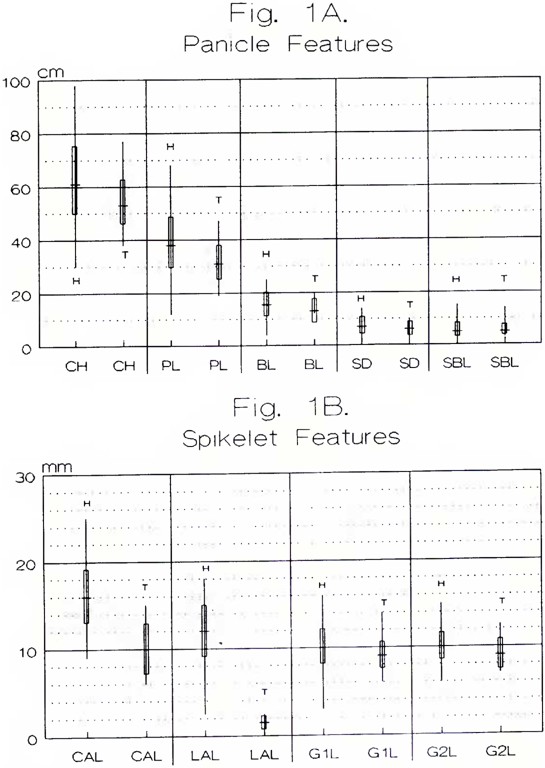


FIG. 1. Range, mean, and 1 one standard deviation for the correlated features of the data set for *Aristida ternipes* (T) and *A. hamulosa* (H). 1A. Panicle features, measured in cm. CH = culm height; PL = plant height; BL = primary branch length, SD = distance to first spikelet, SBL = secondary branch length. 1B. Spikelet features, measured in mm. CAL = central awn length; LAL = lateral awn length; G1L = first glume length; G2L = second glume length.

TABLE 2. Correlation coefficients greater than 0.500 of all variables for *Aristida hamulosa* and *A. ternipes* using all OTUs. Acronyms according to Table 1.

	CULMHT	PANL	PRIBRNL	CAWNL	FSTGLUML	SECGLUML
PANL	0.856	1.000	—	—	—	—
PRIBRNL	0.795	0.856	1.000	—	—	—
SPKLTDIS	0.643	0.635	0.749	—	—	—
SECBRNL	—	0.512	—	—	—	—
LATAWNL	—	—	—	0.835	—	—
SECGLUML	—	—	—	0.639	0.839	1.000
FLORETL	—	—	—	—	0.541	0.504
CALLUSL	—	—	—	—	—	0.526

the OTUs based on this feature. However, the range in lateral awn lengths varied continuously from *hamulosa* to *ternipes*.

The principal components analysis was conducted using the same set of correlated features. The placement of the OTUs along the first component (PCI) was correlated with over-all size features such as panicle length (0.93), longest primary branch length (0.92), culm height (0.91), and distance to the first spikelet on the branch (0.79). The second component (PCII) revealed differences in spikelet features, including second glume length (0.89), first glume length (0.86), and floret length (0.85). The third component (PCIII) emphasized lateral awn length (0.91) and central awn length (0.82). The three components accounted for 75 percent of the variability altogether.

The phenetic distribution of the OTUs along PCI and PCII, which were size and spikelet components, revealed no discernible separation of taxa, and those plots are not shown here. But a segregation of OTUs was achieved along the third component, based on awn lengths (Figure 2). To test the validity of a partition based on lateral awn length, a stepwise discriminant analysis was performed that used this character as the a priori grouping variable but not in calculating the discriminant function. The plot of the OTUs along the canonical variate (Figure 3A) indicated that two groups were distinguished; central awn length was the only variable used in calculation of the discriminant function. However, when both lateral and central awn lengths were removed from the analysis, an extensive intermingling of the OTUs resulted (Figure 3B), and the discriminant function assigned only 69% of the *hamulosa* OTUs and 60% of the *ternipes* OTUs to the "correct" a priori group.

The results of the statistical analyses indicated that 1) there was a nearly continuous range of morphologic variation from one taxon to the other, with extensive overlap in the ranges of individual variables; 2) two contiguous groups of OTUs were segregated based on awn lengths; and 3) no other basis existed, other than awn lengths, for distinguishing the groups.

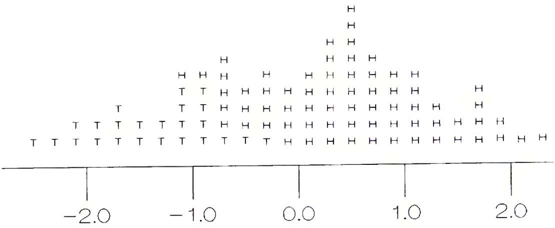
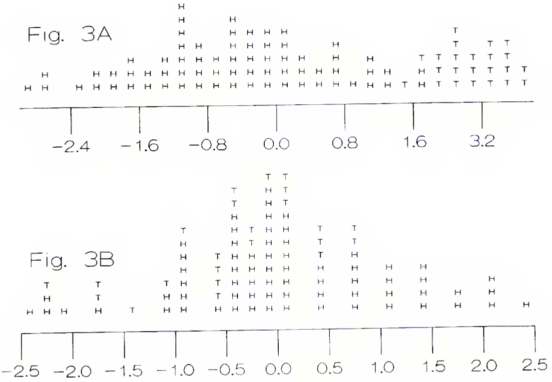


Fig. 2. Principal Component III

FIG. 2. Projection of *Aristida ternipes* (T) and *A. hamulosa* (H) OTUs along principal component III.



Canonical Variable

FIG. 3. Histograms of *Aristida ternipes* (T) and *A. hamulosa* (H) OTUs along the canonical variable of the discriminate analysis. The grouping variable was lateral awn length. 3A. Histogram when only lateral awn length was removed from the data set. 3B. Histogram when both lateral awn and central awn lengrhs were removed from the data set.

Other Observations. Field and herbarium studies yielded other important observations. Noted for the first time for both taxa was the consistent occurrence of long, weak hairs at the base of the blade above the ligule. Also characteristic were glabrous collars, an untwisted awn column, and anthers generally longer than 1.2 mm. These features distinguished the *hamulosa* and *ternipes* entities from the similar-appearing *A. divaricata* Willd. and *A. havardii* Vasey (commonly known as *A. barbata* Fourn.).

Both taxa were found in Texas, New Mexico, and Arizona and throughout most of Mexico. Only the *hamulosa* entity was found in southern California and southern Colorado, and extended as far south as Honduras, but specimens of *ternipes* were found from Nicaragua, Costa Rica, the Bahamas, Venezuela, and Columbia, where *hamulosa* was absent. When sympatric, the two often grew intermingled in the same apparent population and there were no noticeable differences in soil or microsite preferences. The *hamulosa* taxon has spread to slightly more temperate areas in California and Colorado, and *ternipes* perhaps represents a more subtropical form.

Specimens of *hamulosa* from California tended to be short in height, with correspondingly short primary panicle branches. The spikelets were also spaced somewhat closer together. The overall effect of these differences was a slightly more congested look to the panicle. California plants could not be distinguished from non-California plants on this basis, however, and numerous small plants with short branches were found within populations from other regions. *Aristida ternipes* was not found from California.

Commonly, branchlets and spikelets were appressed to the axis of the panicle branch (Figure 4A). However, forms with spreading to divaricate branchlets or pedicels were occasionally found in both taxa. This condition was always associated with pulvini in the axils of the branchlets and pedicels, causing them to spread outward from their axes (Figure 4B). The expression of the pulvini was measured by the branching index in the morphometric analysis and was not highly correlated with any other feature. Our field observations confirmed this: pulvini seemed to develop arbitrarily in many different populations and both spreading and appressed forms of *Aristida ternipes* and *A. hamulosa* were found in the same population. However, spreading forms transplanted to a greenhouse maintained this feature the following growing season, and pulvini did not appear to be a maturation phenomenon, but were observed in the inflorescences from the time they emerged from the sheath until senescence of the plant. The geographic distribution of the spreading forms was centered in the southwestern United States and northern Mexico, with few specimens found

FIG. 4. Spreading and appressed inflorescence forms. A. Inflorescence of a specimen of *Aristida hamulosa* showing the appressed form. B. Inflorescence of a specimen of *Aristida ternipes* showing the spreading form.

from California or southern Mexico. Spreading forms are likewise found in other species of *Aristida*, including *A. pansa*, *A. dissita*, *A. divaricata*, and *A. havardii*. The spreading form of *A. hamulosa*, in particular, may be confused with *A. havardii* or *A. divaricata*, but is distinguished by shorter anthers (≤ 1 mm) and glabrous ligular region in the latter species.

Conclusions and Taxonomy. *Aristida ternipes* and *A. hamulosa* are nearly identical morphologically. Apart from the difference in lateral awn length, the two can scarcely be distinguished. Their over-all geographic distributions have considerable overlap, they are found in the same habitats and in intermingling populations, they both display a distinctive pubescence near the ligule, and they share a seemingly arbitrary expression of pulvini in the panicle. A chromosome level of $2n = 44$ has been reported for both taxa (Gould 1966, 1968; Stebbins & Love 1941). The recognition of two species based on differences in lateral awn length is unwarranted. Eventhough the two entities can be distinguished only by a single feature, suggesting forma status, we propose recognizing the variation in this complex at the varietal level. This is consistent with treatments of similar variation patterns in other Aristida species and with the widespread lack of sharp boundaries in general between taxa in many North American Aristida (Allred 1984a,b, 1985). Given the priority of *A. ternipes* in publication date, the correct classification of the *ternipes* and *hamulosa* entities would be within the single species *A. ternipes* with two varieties, var. *ternipes* and var. *hamulosa*. The necessary combination for the latter variety is effected below.

ARISTIDA TERNIPES Cav. var. HAMULOSA (Henrard) Trent, comb. nov. — BASIONYM: *Aristida hamulosa* Henrard, Med. Rijks. Herb. Leiden 54:219. 1926. TYPE: ARIZONA. Tucson, 30 Sep 1894, *J.W.Toumey s.n.*.

Salient features of the two varieties are compared below:

	var. *ternipes*	var. *hamulosa*
Lateral awn length	0 – 2.5 mm	(2.5)3.5 – 18 mm
Central awn length	5 – 15 mm	10 – 25 mm
Distribution	TX, NM, AZ, Mexico, C. Amer., S. Amer.	TX, NM, AZ, CO, CA, Mexico, Guatemala

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